Lecture Outlines PowerPoint

Chapter 9

Earth Science 11e

Tarbuck/Lutgens

Earth Science, 11e

Volcanoes and Other Igneous Activity
Chapter 9

Volcanic eruptions

- Factors that determine the violence of an eruption
  - Composition of the magma
  - Temperature of the magma
  - Dissolved gases in the magma
- Viscosity of magma
  - Viscosity is a measure of a material's resistance to flow

Volcanic eruptions

- Viscosity of magma
  - Factors affecting viscosity
    - Temperature (hotter magmas are less viscous)
    - Composition (silica content)
      - High silica – high viscosity (e.g., rhyolitic lava)
      - Low silica – more fluid (e.g., basaltic lava)
    - Dissolved gases (volatiles)
      - Mainly water vapor and carbon dioxide
      - Gases expand near the surface

Volcanic eruptions

- Viscosity of magma
  - Factors affecting viscosity
    - Dissolved gases (volatiles)
      - Provide the force to extrude lava
      - Violence of an eruption is related to how easily gases escape from magma
        - Easy escape from fluid magma
        - Viscous magma produces a more violent eruption

Materials associated with volcanic eruptions

- Lava flows
  - Basaltic lavas are more fluid
  - Types of lava
    - Pahoehoe lava (resembles braids in ropes)
    - Aa lava (rough, jagged blocks)
- Gases
  - One to five percent of magma by weight
  - Mainly water vapor and carbon dioxide

A Pahoehoe lava flow

A typical aa flow

Figure 9.5 B

Materials associated with volcanic eruptions

- ❖Pyroclastic materials
  - "Fire fragments"
  - Types of pyroclastic material
    - Ash and dust – fine, glassy fragments
    - Pumice – from "frothy" lava
    - Lapilli – "walnut" size
    - Cinders – "pea-sized"
    - Particles larger than lapilli
      - Blocks – hardened lava
      - Bombs – ejected as hot lava

A volcanic bomb

Bomb is approximately 10 cm long

Figure 9.6

Volcanoes

- General features
  - Conduit, or pipe carries gas-rich magma to the surface
  - Vent, the surface opening (connected to the magma chamber via a pipe)
  - Crater
    - Steep-walled depression at the summit
    - Caldera (a summit depression greater than 1 km diameter)

Volcanoes

- General features
  - Parasitic cones
  - Fumaroles
- Types of volcanoes
  - Shield volcano
    - Broad, slightly domed
    - Primarily made of basaltic (fluid) lava
    - Generally large size
    - e.g., Mauna Loa in Hawaii

Shield volcano

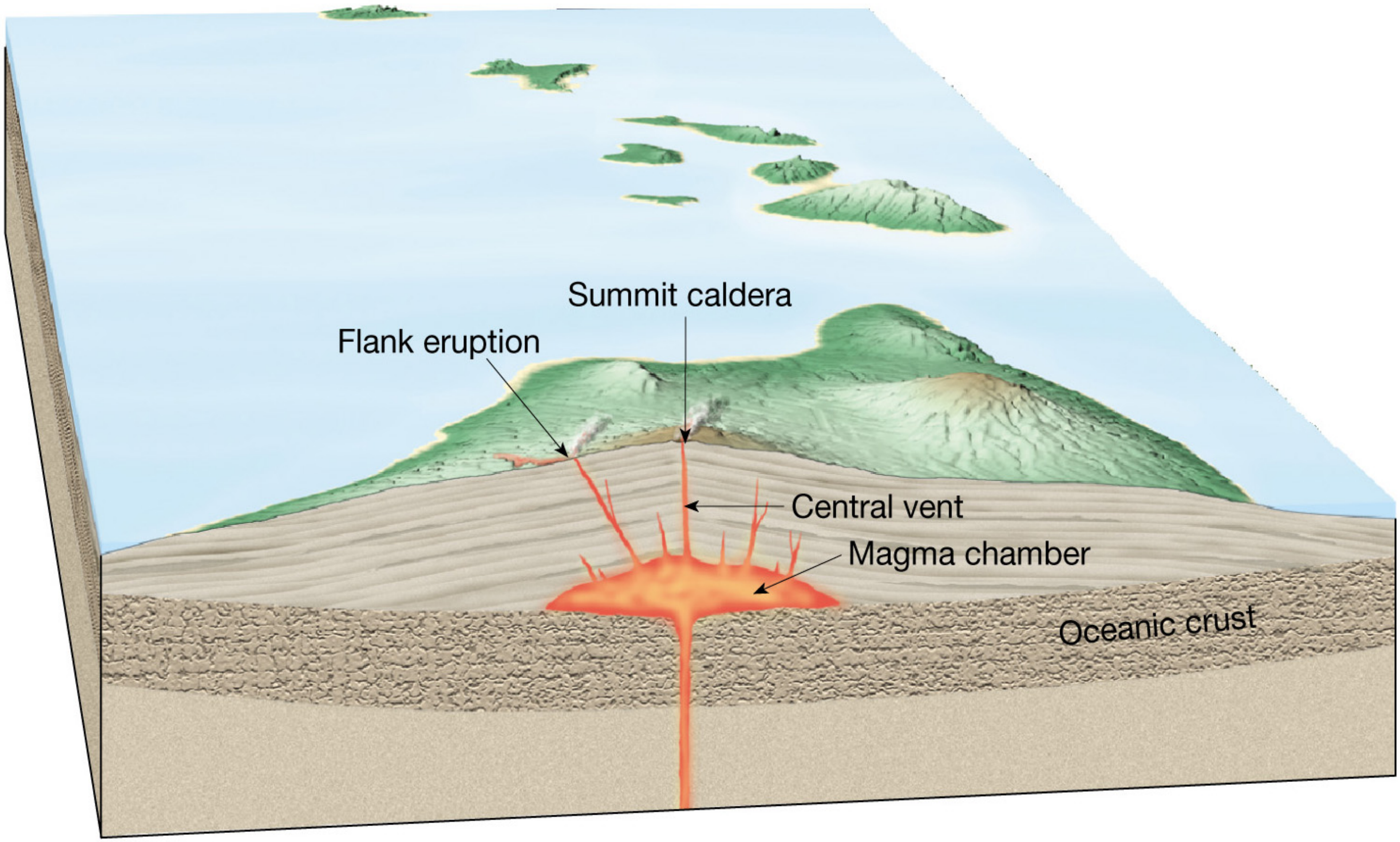


Figure 9.8

Volcanoes

- Types of volcanoes
  - Cinder cone
    - Built from ejected lava fragments
    - Steep slope angle
    - Rather small size
    - Frequently occur in groups

Cinder cone

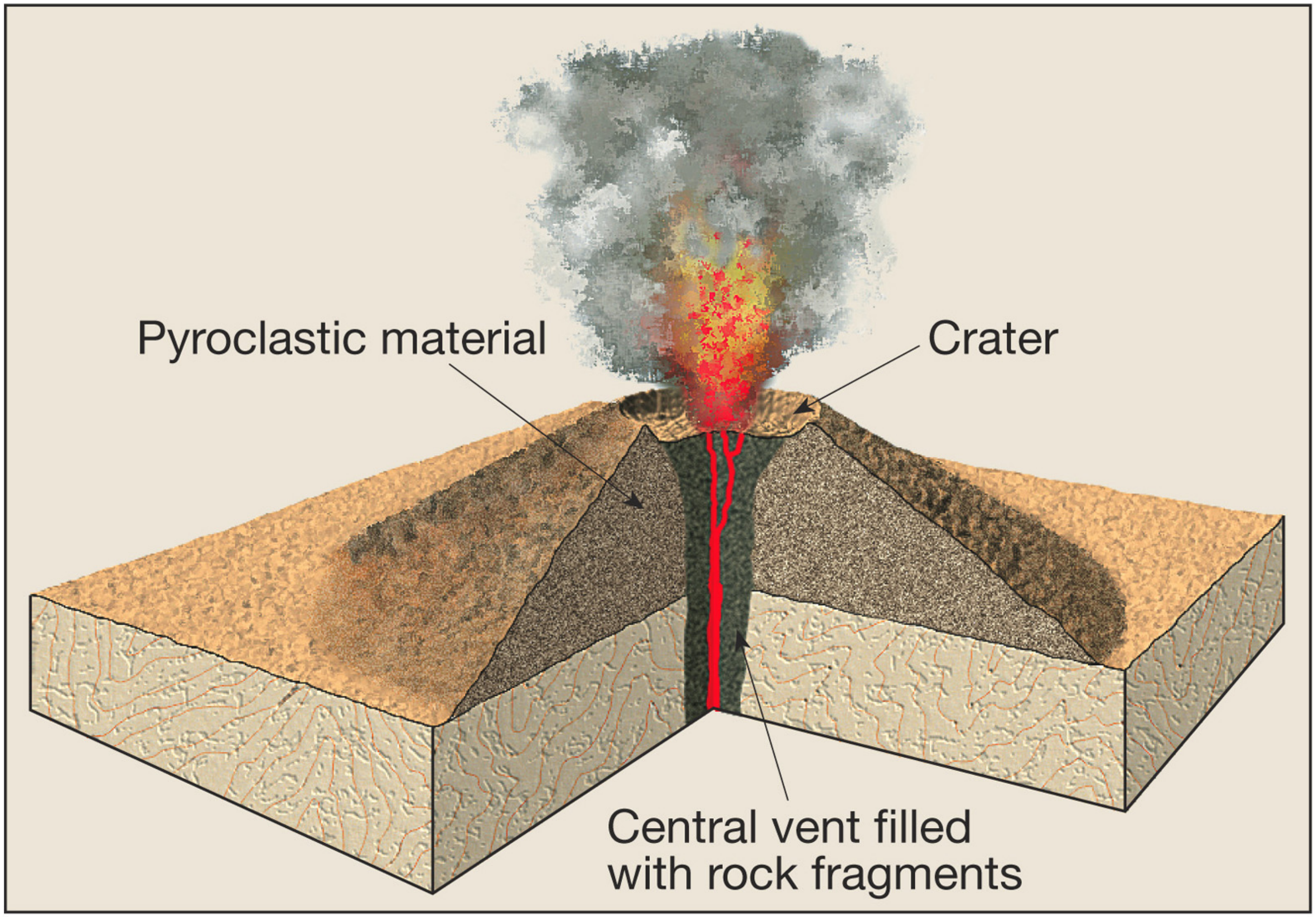


Figure 9.11

Volcanoes

- Types of volcanoes
  - Composite cone (or stratovolcano)
    - Most are adjacent to the Pacific Ocean (e.g., Mt. Rainier)
    - Large size
    - Interbedded lavas and pyroclastics
    - Most violent type of activity

Composite volcano

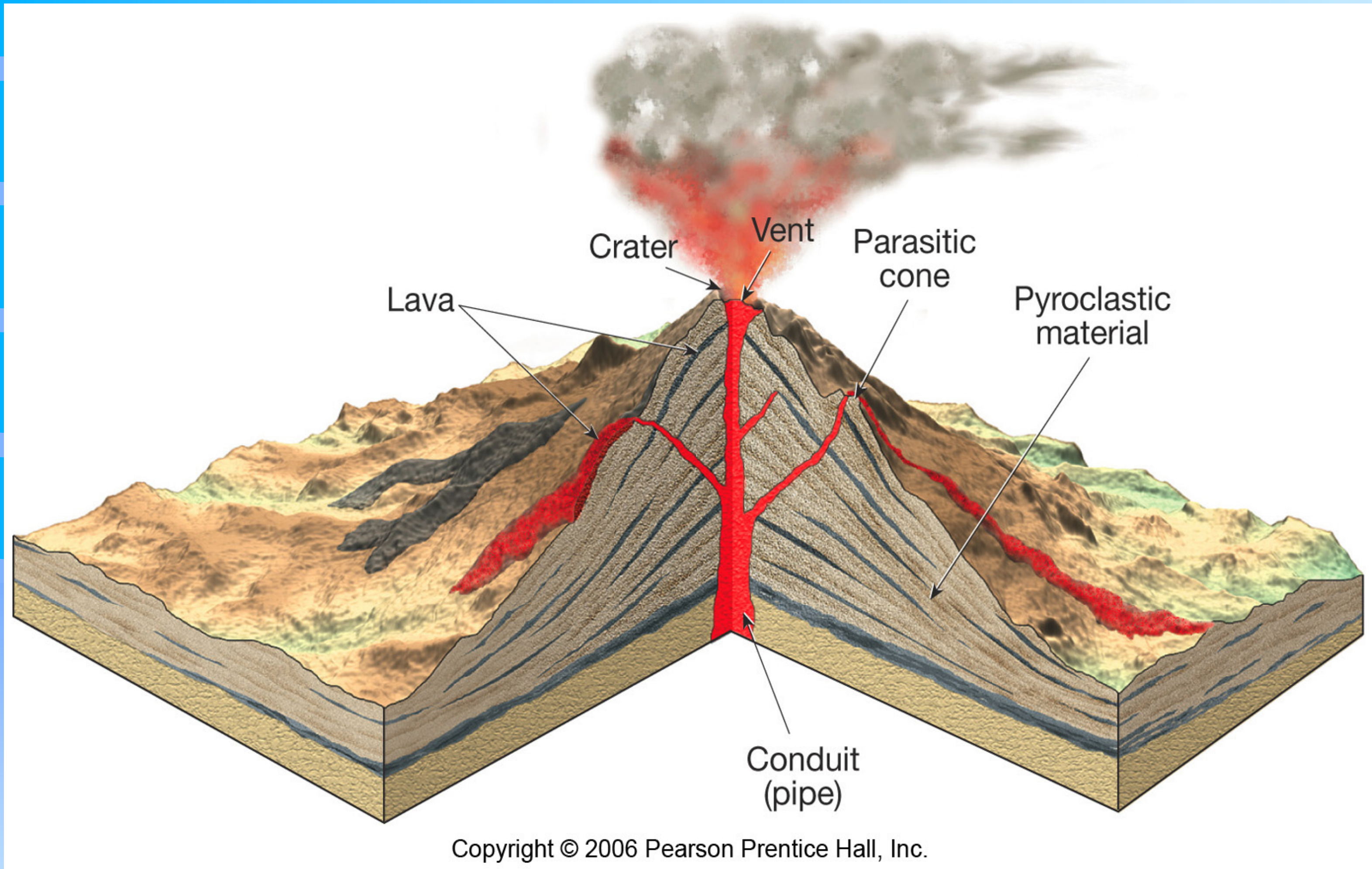


Figure 9.7

Mt. St. Helens – a typical composite volcano

Mt. St. Helens following the 1980 eruption

A size comparison of the three types of volcanoes

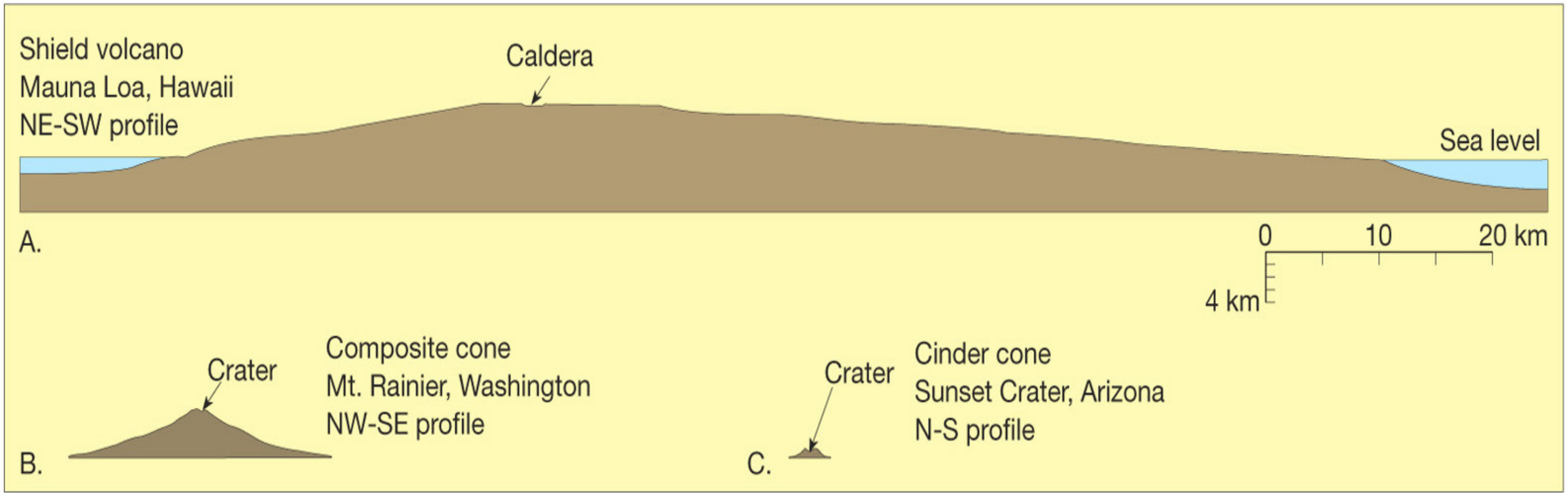


Figure 9.9

Volcanoes

- Types of volcanoes
  - Composite cone (or stratovolcano)
    - Often produce nuée ardente
      - Fiery pyroclastic flow made of hot gases infused with ash
      - Flows down sides of a volcano at speeds up to 200 km (125 miles) per hour
    - May produce a lahar - volcanic mudflow

A nueeé ardente on Mt. St. Helens

Figure 9.14

A lahar along the Toutle River near Mt. St. Helens

Figure 9.16

Other volcanic landforms

- Calderas
  - Steep walled depression at the summit
  - Formed by collapse
  - Nearly circular
  - Size exceeds one kilometer in diameter
- Fissure eruptions and lava plateaus
  - Fluid basaltic lava extruded from crustal fractures called fissures
  - e.g., Columbia Plateau

Crater Lake, Oregon is a good example of a caldera

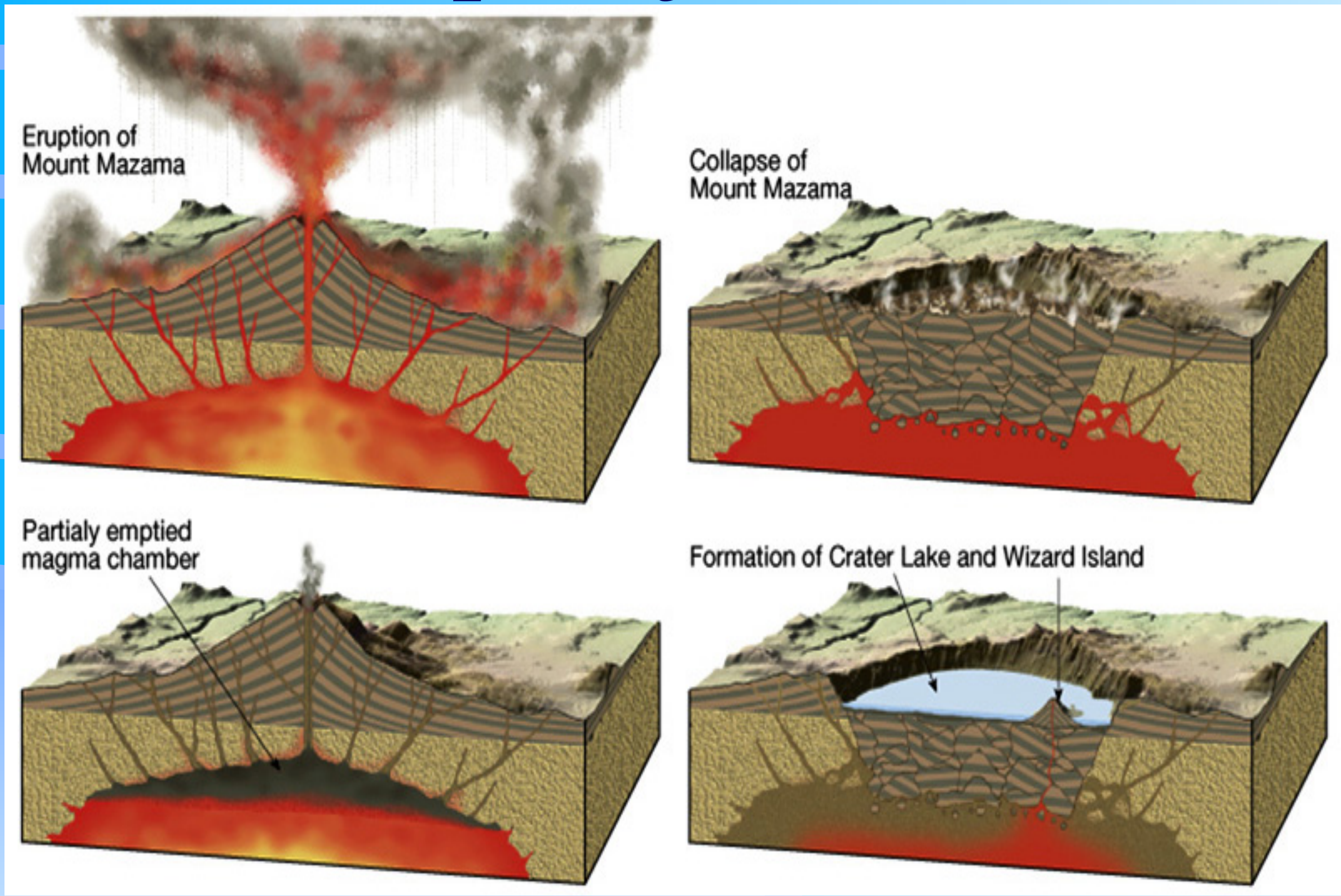


Figure 9.17

Crater Lake in Oregon

Figure 9.18

The Columbia River basalts

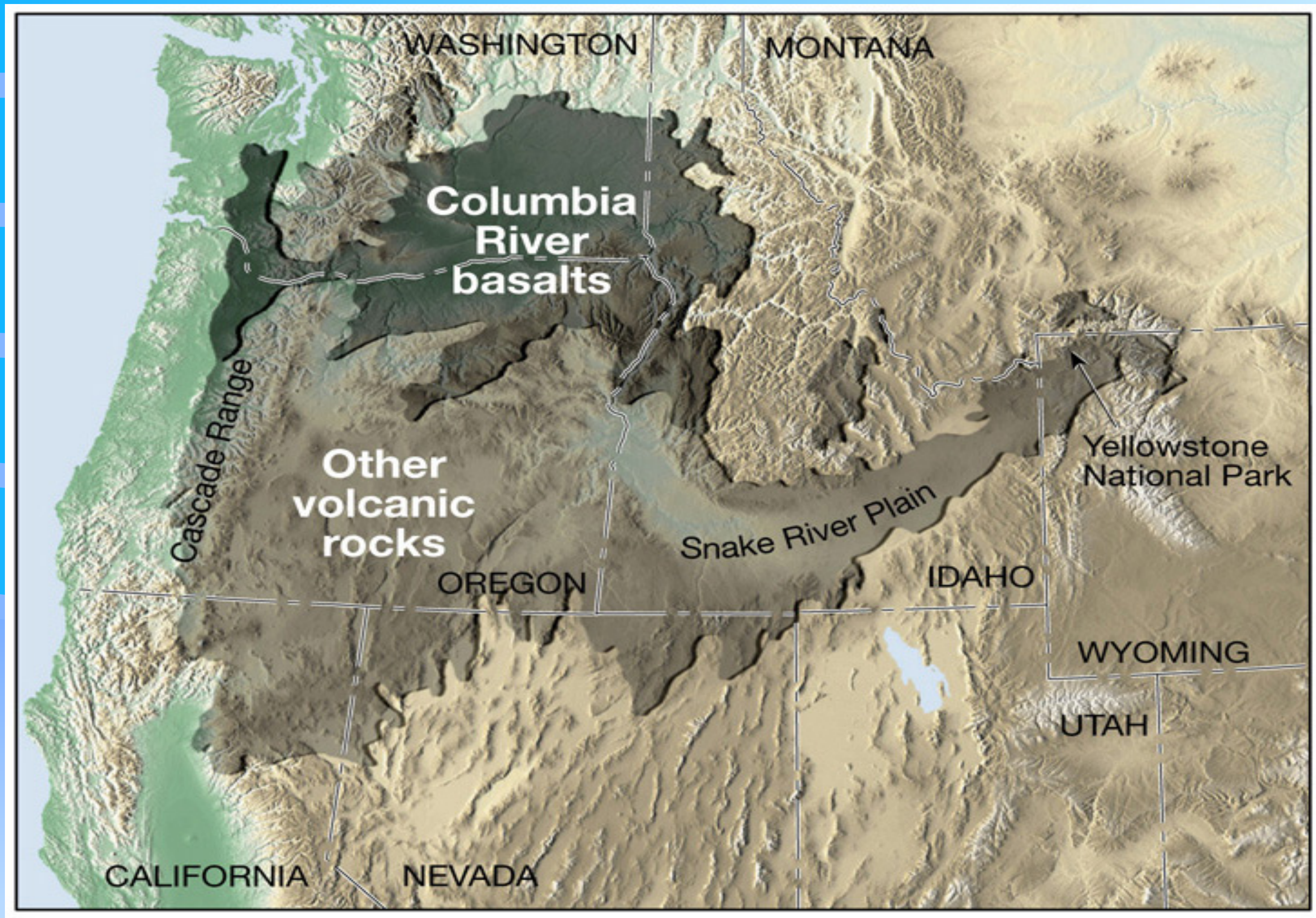
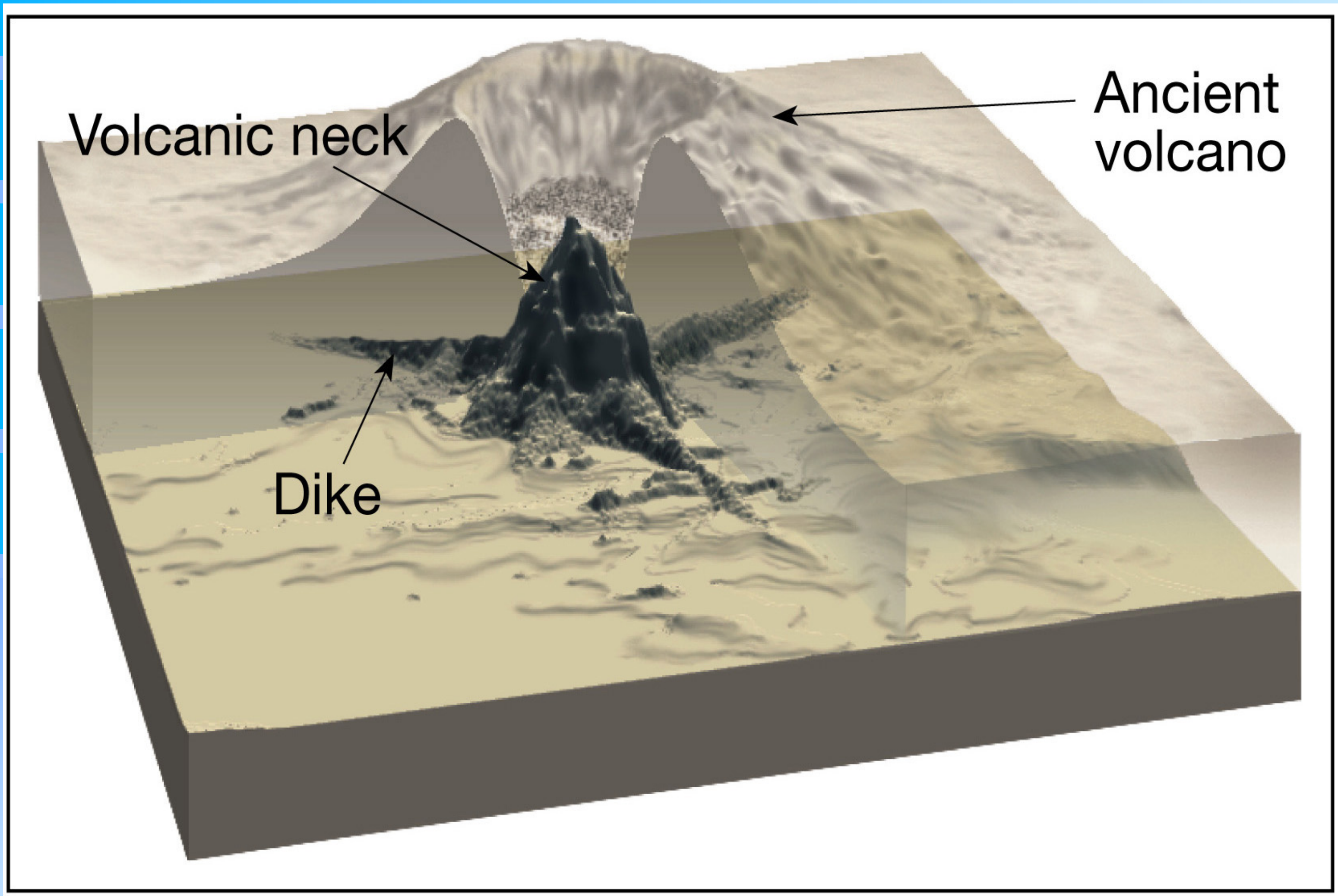


Figure 9.19

Other volcanic landforms

- Volcanic pipes and necks
  - Pipes are short conduits that connect a magma chamber to the surface
  - Volcanic necks (e.g., Ship Rock, New Mexico) are resistant vents left standing after erosion has removed the volcanic cone

Formation of a volcanic neck



Intrusive igneous activity

- Most magma is emplaced at depth
- An underground igneous body is called a pluton
- Plutons are classified according to
  - Shape
    - Tabular (sheetlike)
    - Massive

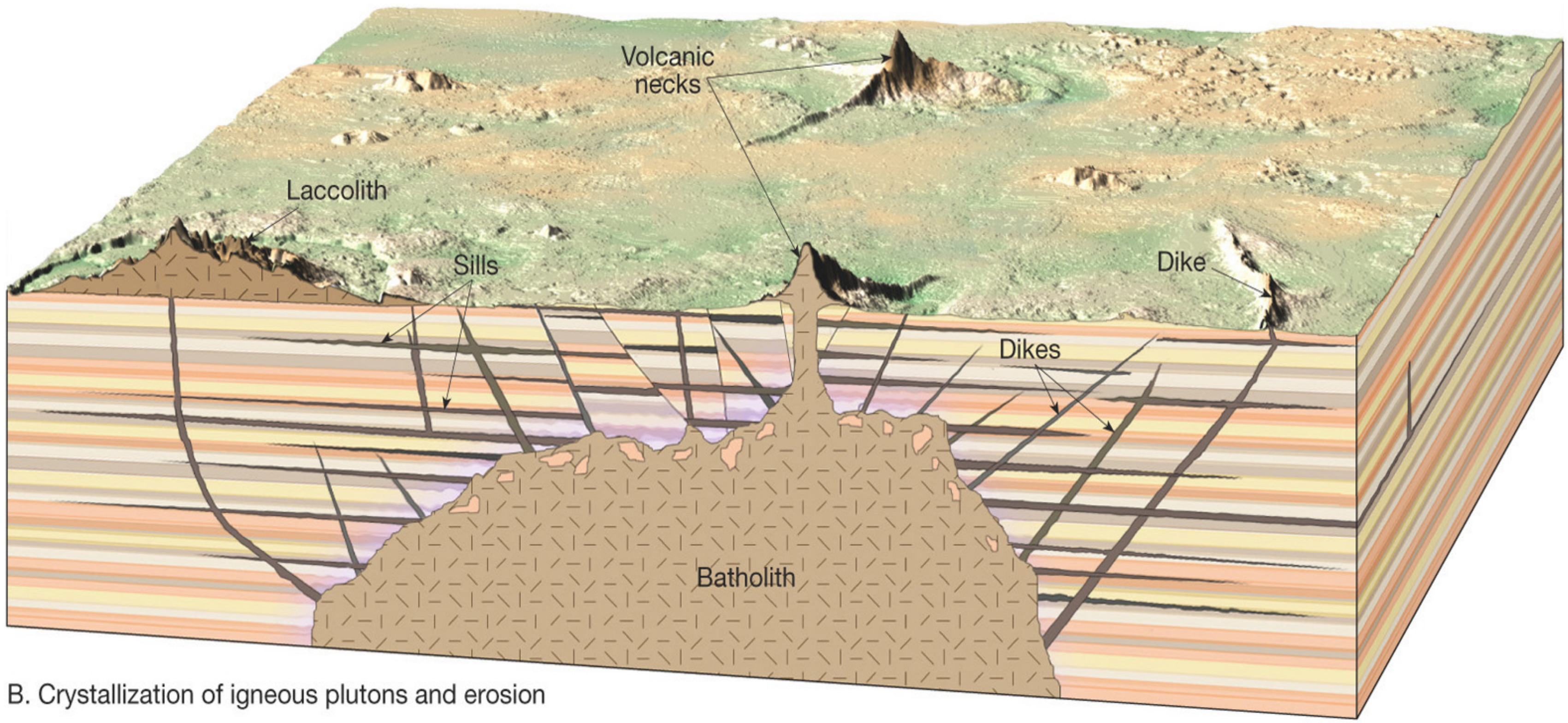
Intrusive igneous activity

- Plutons are classified according to
  - Orientation with respect to the host (surrounding) rock
    - Discordant – cuts across existing structures
    - Concordant – parallel to features such as sedimentary strata

Intrusive igneous activity

- Types of igneous intrusive features
  - Dike, a tabular, discordant pluton
  - Sill, a tabular, concordant pluton
    - e.g., Palisades Sill, NY
    - Resemble buried lava flows
    - May exhibit columnar joints
  - Laccolith
    - Similar to a sill

Intrusive igneous structures exposed by erosion



B. Crystallization of igneous plutons and erosion

Figure 9.22 B

A sill in the Salt River Canyon, Arizona

Figure 9.23

Intrusive igneous activity

- Types of igneous intrusive features
  - Laccolith
    - Lens shaped mass
    - Arches overlying strata upward
  - Batholith
    - Largest intrusive body
    - Often occur in groups
    - Surface exposure 100+ square kilometers (smaller bodies are termed stocks)
    - Frequently form the cores of mountains

A batholith exposed by erosion

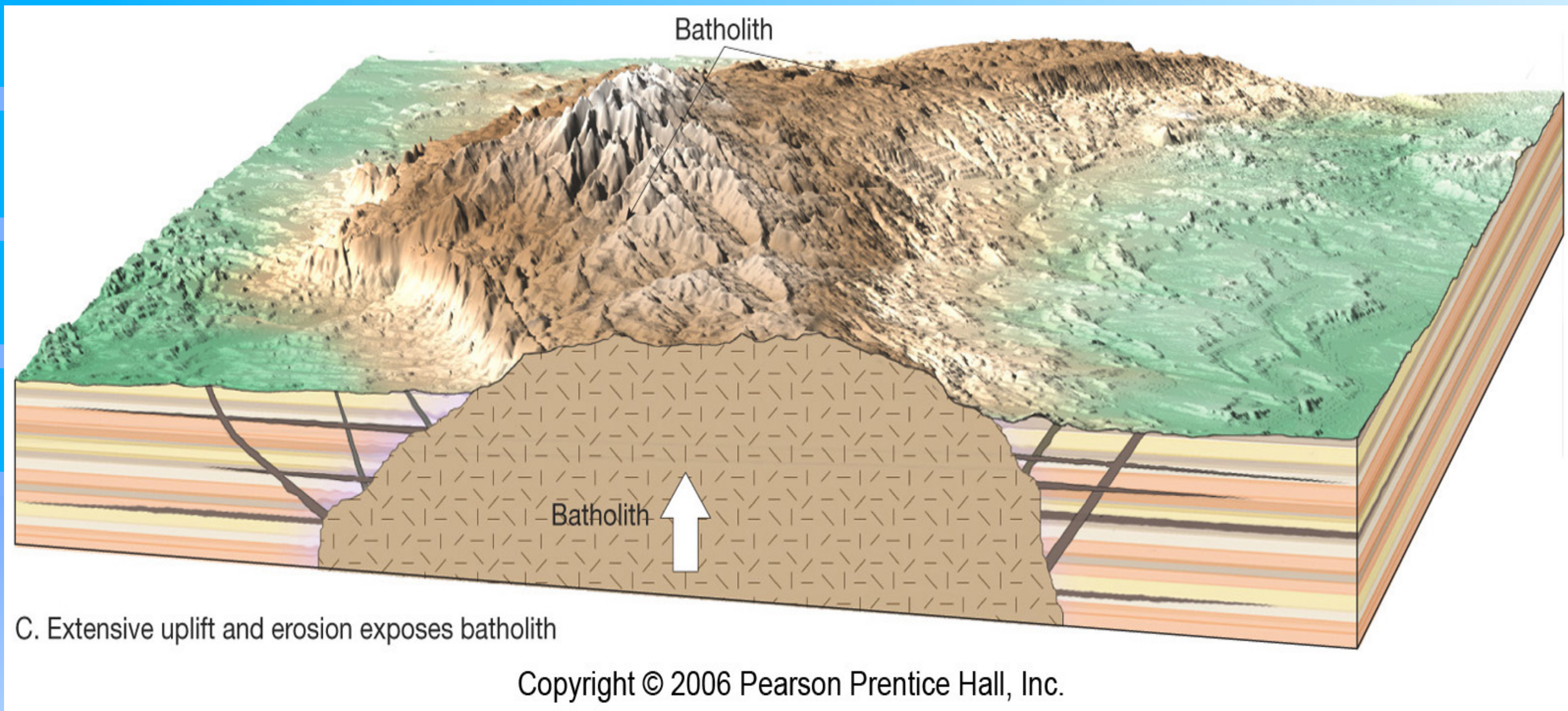


Figure 9.22 c

Origin of magma

- Magma originates when essentially solid rock, located in the crust and upper mantle, melts
- Factors that influence the generation of magma from solid rock
  - Role of heat
    - Earth's natural temperature increases with depth (geothermal gradient) is not sufficient to melt rock at the lower crust and upper mantle

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Role of heat
    - Additional heat is generated by
      - Friction in subduction zones
      - Crustal rocks heated during subduction
      - Rising, hot mantle rocks

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Role of pressure
    - Increase in confining pressure causes an increase in melting temperature
    - Drop in confining pressure can cause decompression melting
      - Lowers the melting temperature
      - Occurs when rock ascends

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Role of volatiles
    - Primarily water
    - Cause rock to melt at a lower temperature
    - Play an important role in subducting ocean plates

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Partial melting
    - Igneous rocks are mixtures of minerals
    - Melting occurs over a range of temperatures
    - Produces a magma with a higher silica content than the original rock

Plate tectonics and igneous activity

- Global distribution of igneous activity is not random
  - Most volcanoes are located on the margins of the ocean basins (intermediate, andesitic composition)
  - Second group is confined to the deep ocean basins (basaltic lavas)
  - Third group includes those found in the interiors of continents

Locations of some of Earth's major volcanoes

Figure 9.28

Plate tectonics and igneous activity

❖Plate motions provide the mechanism by which mantle rocks melt to form magma

- Convergent plate boundaries
  - Descending plate partially melts
  - Magma slowly rises upward
  - Rising magma can form
    - Volcanic island arcs in an ocean (Aleutian Islands)
    - Continental volcanic arcs (Andes Mountains)

Plate tectonics and igneous activity

- Plate motions provide the mechanism by which mantle rocks melt to form magma
  - Divergent plate boundaries
    - The greatest volume of volcanic rock is produced along the oceanic ridge system
      - Lithosphere pulls apart
      - Less pressure on underlying rocks
      - Partial melting occurs
      - Large quantities of fluid basaltic magma are produced

Plate tectonics and igneous activity

- Plate motions provide the mechanism by which mantle rocks melt to form magma
  - Intraplate igneous activity
    - Activity within a rigid plate
    - Plumes of hot mantle material rise
    - Form localized volcanic regions called hot spots
    - Examples include the Hawaiian Islands and the Columbia River Plateau in the northwestern United States

End of Chapter 9